Portland General Electric Company
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March 12, 2020

Via Electronic Filing

Public Utility Commission of Oregon
Attention: Filing Center
P.O. Box 1088
Salem, OR 97308-1088

Re: UM 1856 Portland General Electric Company's Revised Residential Storage Pilot Proposal

Dear Filing Center:

Pursuant to Oregon Public Utility Commission (OPUC or Commission) Order No. 18-290, enclosed is Portland General Electric Company's (PGE's) revised Residential Storage Pilot Proposal for Public Utility Commission of Oregon (OPUC) Staff review.

Pilot Summary

The proposed pilot targets 525 (2-4 MW or 6-8MWh) of controllable behind-the-meter energy storage systems in residential homes. The pilot's purpose is to explore the ability of distributed assets to provide grid services, learn how to deploy assets with benefit streams shared between participants and all PGE customers, and develop best practices for integrating distributed resources into existing assets control systems. The pilot will test customer acceptance of utility operation of batteries, explore hurdles to adoption, and understand residential resiliency needs.

PGE will dispatch the energy storage systems in aggregate for grid services, including autonomous volt/var support, autonomous frequency response, generation capacity, energy resource optimization, and contingency reserves. Results of the testing will inform future valuation for distributed energy storage on PGE's system and evaluate the potential for distribution upgrade deferral and other locational benefits. Customers may utilize the batteries during an outage for added power reliability.

Background

The Commission opened Docket No. UM 1751, in September 2015, to implement House Bill 2193. This House Bill requires large Oregon electric companies (i.e., Pacific Power or Pac, and PGE) to submit proposals by January 1, 2018, to develop qualifying energy storage systems with the capacity to store at least five megawatt hours. In UM 1751, the Commission adopted specific guidelines and requirements for energy storage project proposals, in late 2016, and a framework for Pac's and PGE's Energy Storage Potential Evaluations (Potential Evaluations) in March 2017.

PGE filed its Energy Storage Proposal and Final Potential Evaluation on November 1, 2017, investigated in the subsequently opened UM 1856. Following multiple rounds of testimony, numerous data requests, workshops, and a settlement conference; stakeholders and the company reached a Partial Stipulation and submitted Joint Testimony in support, which was approved in Commission Order No. 18-290. Pursuant to the terms and conditions of the stipulation related to the Residential Storage Pilot, PGE filed an addendum to the energy storage proposal on January 25, 2019. After meeting in July, PGE and Staff agreed that PGE would revise the pilot design, under the terms of the stipulation, to address Staff's concerns. PGE met with Staff on January 27, 2020 and February 14, 2020 to present and discuss a draft of the revised proposal. Attachment A of this filing represents the final proposal and includes the following aspects of the pilot: objectives, benefits, detailed design, costs for customers and PGE, use cases, and a description of the evaluation reports PGE will file with Staff in accordance with the stipulation approved in Order No. 18-290.

Upon Staff's completion of the Pilot Proposal, PGE plans to file a pilot operating tariff in April of 2020 with a projected effective date of May of 2020.

PGE looks forward to working with Staff as they review this filing in accordance with Order No. 18-290. Please direct questions regarding this filing to Chris Pleasant at (503) 464-2555.

Please direct all formal correspondence and requests to the following email address pge.opuc.filings@pgn.com

Sincerely,

Robert Macfarlane
Manager, Pricing and Tariffs

RM/np
Enclosure
cc: UM 1856 Service List
Nicholas Colombo, OPUC

UM 1856

Attachment A

PGE's Revised Residential Storage Pilot

Residential Battery Storage Pilot Proposal

UM 1856 | March 2020

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Acronyms

ADMS…Advanced Distribution Management System
API……. Application Programming Interface
BAO….. Balancing authority operations
CERT…. Citizen Emergency Response Team
DER…….Distributed Energy Resource
DR .... Demand Response
DSG…….Dispatchable Standby Generation
EIM…… Energy Imbalance Market
EPRI….. Electric Power Research Institute
IRP .... Integrated Resource Plan
ITC……. Investment Tax Credit
MVP…..Minimum Viable Product
NET……Neighborhood Emergency Team
NERC….North American Energy Reliability Corporation
NET…….Neighborhood Emergency Team
NFPA… National Fire Protection Association
NPV ..... Net Present Value
NREL…..National Renewable Energy Laboratory
O&M ... Operations and Maintenance
OPUC... Oregon Public Utility Commission
PBEM... Portland Bureau of Emergency Management
PGE...... Portland General Electric
PNNL…. Pacific Northwest National Laboratory
PV…….. Photovoltaic
QPL…….Qualified Products List
RFI……. Request for Information
RFP…….Request for Proposal
RTE……Round Trip Efficiency
SOW….Scope of Work
T&D……Transmission & Distribution
TOU ..... Time of Use
WECC….Western Electricity Coordinating Council

Executive Summary

Portland General Electric (PGE) is committed to building a cleaner energy future for Oregon, with a goal of reducing greenhouse gas emissions by more than 80 percent by 2050[1]. For the past eight years, PGE customers have made our voluntary renewable power program the biggest green power program in the country. PGE customers and the Energy Trust of Oregon ("Energy Trust") have also helped make PGE one of the top 10 utilities in the nation for energy efficiency.[2] We are on track to meet (and likely exceed) the legislative mandate that 50 percent of our customers' energy come from qualified renewable resources by 2040.

Energy storage, including residential behind-the-meter storage, will be a key part of our strategy to meet these clean energy goals. Renewable resources are inherently variable, and it will be increasingly important for PGE to integrate technologies supporting grid flexibility to make sure that power is always available to meet our customers' needs. Likewise, growing customer demand for resilient power systems indicates that PGE must also integrate technologies that support customers' ability to sustain power during major outage events. Residential battery energy storage can provide a range of grid services to provide the flexibility and resiliency needed to support PGE's transition to a clean energy future.

To advance Oregon's carbon reduction and clean energy goals, Oregon's state legislature passed Chapter 312 in 2015, mandating that PGE procure at least 5 MWh – and up to one percent of 2014 peak load (38.7 MW for PGE) – of energy storage by 2020. In support of this legislation, the Oregon Public Utility Commission (OPUC) encouraged PGE to "submit multiple, differentiated projects that test varying technologies or applications" in its guidelines for proposal submissions.

This proposal outlines PGE's Residential Storage Pilot, as partially approved by Order No. 18-290. The proposed Pilot targets 525 behind-the-meter battery energy storage systems in residential customer homes. PGE will explore the ability of distributed assets to provide grid services, learn how to deploy assets with benefit streams shared between participants and all PGE customers, and develop best practices for integrating distributed resources into existing asset control systems. The pilot will test customer acceptance of utility operation of their battery and explore hurdles to adoption and to better understand residential resiliency needs.

In aggregate, the pilot aims to realize 2-4 MW/6-8 MWh of controllable energy storage that PGE can dispatch in aggregate for grid services, including autonomous Volt/Var support, autonomous frequency response, generation capacity, energy resource optimization, and contingency reserves. PGE would use the results of the testing to inform future valuation of distributed energy storage on our system, as well as evaluate the potential for distribution upgrade deferral and other locational benefits. Customers would utilize the batteries during an outage for added power reliability.

[1] PGE 2019 Integrated Resource Plan
[2] ACEEE 2020 Utility Energy Efficiency Scorecard

Section 1. Background

The 2015 Oregon legislative session enacted House Bill (HB) 2193, requiring Oregon electric companies (PGE and PacifiCorp) to submit proposals by January 1, 2018, to procure qualifying energy storage systems with capacity to store at least five megawatt hours of energy. The Commission opened Docket No. UM 1751 in September 2015 to implement HB 2193, and, in Commission Order No. 16-504, adopted guidelines and requirements for energy storage proposals and a framework for the Energy Storage Potential Evaluations. This order encouraged PGE to "submit multiple, differentiated projects that test varying technologies or applications."

PGE filed its energy storage proposal and final Energy Storage Potential Evaluation on November 1, 2017. Commission Order No. 18-290 partially approved and modified a stipulation filed by PGE and provided conditional approval for the Residential Storage Pilot.[3] The requirement was for PGE to submit an addendum to OPUC Staff (Staff) that details how it will optimize learnings and mitigate risks. Staff would then evaluate and determine whether PGE provided adequate evidence to allow the Company to move forward with the proposed pilot.

PGE is submitting this application to update its Residential Storage Pilot proposal. This proposal does not change the terms and conditions in the stipulation, rather it provides a more robust plan that better addresses concerns raised by Staff and stakeholders throughout the regulatory process.

[3] This information can be found in Commission Order No. 18-290 at 5.

Section 2. Summary

PGE proposes to leverage battery energy storage systems (or simply, "batteries"), installed on residential customer homes behind the utility electric meter, as a dispatchable resource to provide PGE system services.

As a fleet, the batteries will act in aggregate to provide system services and individually for customer services. PGE has modeled the value of some services; for others, the pilot will seek to establish a value. The pilot intends to aggregate 525 residential batteries totaling 2 to 4 MW in size and 6 to 8 MWh in duration. Each battery will provide between 3 to 6 kW of power output and 12 to 16 kWh of energy storage.

PGE will have full control over battery operations and will charge and dispatch the fleet according to system needs,[4] except in the event of an outage when the batteries will autonomously island to provide home energy back-up. PGE will primarily deploy batteries for the following use cases:

- Distribution use cases:
    - Localized demand response
    - Autonomous Volt/Var support
- Generation use cases:
    - Generation capacity
    - Energy resource optimization
    - Contingency reserves
    - Autonomous frequency response
- Customer use case:
    - Outage mitigation

While PGE is focusing initially on the above use cases, they also plan on evaluating the feasibility of other use cases that arise, which may include load following, distribution congestion relief, and distribution upgrade deferral (e.g. system investments to address reliability, operational efficiency, and/or hosting capacity limitations).

PGE has selected the Electric Power Research Institute's (EPRI) open-source Storage Value Estimation Tool (StorageVET®[5]) software for evaluation and will share modeling results and data. The software co-optimizes bulk system and locational benefits based on provided inputs. This modeling will inform PGE's operation of the batteries.

A customer who applies to participate with a qualified battery[6] and who is accepted into the Pilot will be compensated $40 per month, or $20 if the battery is restricted to rooftop photovoltaic (PV) charging only,[7] in exchange for allowing PGE to operate the battery for grid services. PGE will do a concerted effort to make the offering known to Community Emergency Response Team ("CERT")/Neighborhood Emergency Team ("NET")

[4] These services match or are similar to those identified by the Commission in Order No. 17-118 Appendix A.
[5] See Appendix A EPRI StorageVET Modeling for more information.
[6] Qualified battery systems are outlined in section 6.2(d) Qualified Batteries.
[7] Explanation of this approach can be found in section 5.1(a) Base Offering.

volunteers. These trained volunteers have committed to assisting their community in the event of a major disaster.[8]

Customers living within the PGE Smart Grid Test Bed ("Test Bed"), as defined in PGE rate Schedule 13, with a newly installed qualified battery are also eligible to receive a rebate at time of purchase, in addition to the monthly payments. This offer seeks to drive density within select substations to achieve sufficient density to test locational benefits.[9]

PGE is also partnering with the Energy Trust to address potential barriers to residential storage for income-constrained customers. Customers participating in the Energy Trust's Solar Within Reach[10] program who install a qualified battery are eligible for a $5,000 rebate in addition to the monthly bill credits. These customers may reside anywhere within PGE's service territory.[11]

All battery systems will be customer owned, with the requirement that an Energy Trust solar trade ally install any systems receiving a rebate. Any customers wishing to enroll in the pilot with a qualified battery that is not newly installed by an Energy Trust solar trade ally must be verified[12] prior to acceptance in the pilot to ensure safe operation.

Section 3. Pilot Research Objectives

The key objective of the Residential Battery Storage Pilot is to collect as much information as possible about the impact of residential battery storage in four categories: the Energy Portfolio, the Grid, the Customer, and the Program.

3.1. The Grid

The primary goal of the pilot is to evaluate the ability of residential batteries to deliver locational value in support to PGE's electrical system. The grid value questions this pilot seeks to explore are:

- Explore the effectiveness in shaping load, and the potential for distribution upgrade deferrals
- Evaluate and refine setpoints and settings for advanced inverter capabilities to maximize locational value while maintaining local system reliability and retaining battery longevity
- Understand the effectiveness of batteries to support Volt-Var optimization
- Understand the ability of residential batteries to relieve hosting capacity constraints
- Understand the compatibility of stacked services, and the frequency of conflicting dispatch priorities between locational Grid services and Bulk Energy services

A key pilot finding will be the determination of values for each tested use case, including both generation and locational values. Modeling is useful to estimate these values, but this pilot will serve as a field test to assess the accuracy of the modeling and the actual experiences in customers' homes. Accurate valuation must also reflect

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[8] Explanation of this approach can be found in section 5.1(d) CERT and NET Volunteers.
[9] Explanation of this approach can be found in section 3.1 The Grid.
[10] Additional Solar Within Reach information can be found in Appendix F Solar Within Reach Overview.
[11] Explanation of this approach can be found in section 5.1(c) Income Qualified Rebate Coordination with Energy Trust.
[12] Explanation of this approach can be found in section 6.2(f) "Grandfathered" Battery Installations.

the batteries' ability to integrate with the markets and dispatch entities relevant to each use case. The pilot will explore all value streams and remains open to any learnings obtained through this project. The specific use cases that PGE will be evaluating are autonomous Volt/Var support, autonomous frequency response, BAO dispatch of contingency reserve, and bulk generation capacity deferral, however PGE will also pursue any additional use cases that arise as technically feasible over the course of the pilot.

PGE will explore the services and attendant values agreed to in Order 17-118, Appendix A.[13] Additionally, PGE will investigate the value of these distributed distribution system-sited resources to the bulk grid. Similarly, PGE will explore distribution system values from operating this fleet of batteries—including both local distribution system value and systemwide generation values.

These grid and operational learnings will be captured through quantitative analysis of the batteries' performance, evaluated internally through the EPRI StorageVet tool and externally through a third-party evaluation consultant. All batteries will be integrated into GenOnSys, which is PGE's control software package currently used for the Dispatchable Standby Generation (DSG) program. GenOnSys will provide PGE and the evaluator with access to all the relevant historical data about inverter charge/discharge times, state of charge, and current and voltage levels. Should PGE opt to not dispatch the batteries through GenOnSys for any reason, data will also be stored by the aggregation platform in the utility portal.

Actual dispatch of the battery will be subject to uncertain grid conditions and limitations in real performance. PGE will evaluate the actual dispatch for the grid benefits provided and will use the results to inform future StorageVET® evaluation and modeling. This feedback loop will refine PGE's ability to make informed, economic, and transparent decisions for future storage-related pilots and programs. The grid value learnings are intended to inform PGE's Integrated Resource Plan (IRP) so that residential battery energy storage can be properly valued and a cost-effective scalable program may be developed.

3.2. The Energy Portfolio

The pilot has the potential to stack values relevant to PGE's bulk energy portfolio. The bulk energy value questions this pilot seeks to explore are:

- Evaluate the cumulative number of hours the aggregate residential energy storage resource is dispatched to serve Bulk Energy use cases, and total value accrued for those services
- Test base assumptions around Bulk Energy resources such as load following and primary frequency response
- Determine the accuracy of PGE's modeling inputs to the EPRI StorageVET and its suitability as a planning tool (inform IRP values for use cases)

3.3. The Customer

The pilot will allow PGE to develop operating protocols that balance the needs of the grid with those of individual customers. It will specifically identify how best to extract the greatest value for PGE's investment without

[13] OPUC UM 1751 Order 17-118 https://apps.puc.state.or.us/orders/2017ords/17-118.pdf

jeopardizing customer participation in the pilot. PGE will evaluate Customer Needs around battery energy storage through a combination of qualitative and quantitative analysis. Topics PGE seeks to explore include:

- Acceptance of PGE control of the battery
- Preference for up-front rebate or ongoing compensation
- Hurdles to battery adoption
- Target market most likely to purchase battery storage
- Messaging that customers relate to for value proposition of utility control
- Identification of gaps between battery performance and customer expectation (especially when it comes to longer-duration outages)
- Balancing use of the battery for grid services with customer reserve in the event of an outage
- Device communication performance, uptime, hurdles
- Frequency of opting-out of dispatch
- Average battery state of charge and availability to provide customer backup
- Average number of cycles per year, and effect on battery degradation
- Customer economics of battery usage, potential of TOU optimization

PGE will do this through:

- Baselining customer surveys of awareness, interest, and consideration testing prior to pilot launch
- A/B testing of messaging and outreach
- Ongoing customer surveys of those who enroll in the program on their experiences and satisfaction
- Surveys of those who do not enroll in the program (identified as those who install solar panels through the Energy Trust program but do not purchase a battery) to better understand their barriers, and
- Interviews and/or surveys with installers to understand what questions customers are asking, barriers to installation, and ideas they might have for increased adoption.

The pilot will test the willingness of customers to allow PGE to operate their battery in exchange for payment, and whether PGE's proposed payment is sufficient to encourage pilot participation. A key pilot learning will be whether the monthly payment and up-front rebate amounts are appropriate. PGE is employing a tiered, up-front rebate that will start higher and reduce as customers are enrolled—allowing PGE to test the efficacy of various incentive levels on customer uptake. If the pilot struggles to enroll customers, a second phase of the pilot may involve re-working the offers. Conversely, if the pilot reaches capacity faster than anticipated and has a robust waitlist of interested customers, PGE may consider reducing the incentives in any future pilot expansion.

PGE will work to ensure that the financial design is a favorable alternative to bill management. To that end, PGE will evaluate time of use (TOU) rate optimization and general customer economics throughout the pilot. While a battery controlled by the customer and programmed for TOU rates can effectively shift energy load from one time period to another and provide customer bill management, the full spectrum of use cases diminishes without utility operation of the battery.[14]

[14] For a look at the potential bill management optimization of a battery using TOU, see Appendix B Economic Benefit of Using Battery on Schedule 7-TOU.

3.4. The Program

In addition to learning about customer needs and grid value of battery storage, PGE will utilize the pilot to inform a future recommendation on scalable future program design and the most appropriate business model for PGE in the residential battery storage market. This includes understanding efficiencies that can be achieved through program design, unanticipated costs and hurdles of battery storage implementation, the best practices for aggregated control & dispatch, balancing cost with operations, understanding the full value streams available from batteries so a cost-effective program can be developed, and the ability to strategically select locations for storage to create a program that best utilizes distribution upgrade deferral. Specific questions PGE seeks to address to inform future program design include:

- Study reliability and efficacy of various communications protocols, LTE cellular data vs. wifi
- Understand cost versus benefits of communications methods
- What is the best way to manage integrations of multiple APIs
- Determine actual financial impacts on customer bills, appropriate way to utilize non-utility measurement and metering devices
- Quantify actual Round-Trip Efficiency (RTE) losses of interconnected batteries- vendors report efficiencies under “ideal conditions,” how do customer homes compare to ideal conditions, what is the range of field efficiencies that are observed
- Quantify what increased value is available due to direct control/dispatch from the utility versus passive measures to incent customer behaviors (e.g., TOU)
- Set effective incentive levels to develop a cost-effective scalable program
- Tolerable use cases and battery usage for customer acceptance

While the default option for battery storage communications will be customer-hosted internet (wifi or ethernet), some (though not all) of the batteries on the qualified products list (QPL) have LTE capability that can be activated. PGE will track the effectiveness and availability of customer hosted internet and has selected an aggregation platform with multi-modal messaging to customers whose batteries go offline to remind them to reconnect their device to the internet if they wish to remain in PGE’s pilot. PGE may opt to offer LTE cellular communications to income qualified participants and other customers who are deemed to have insufficient internet coverage and will evaluate the costs versus benefits of utilizing customer internet versus PGE hosted LTE cellular data.

3.4(a) Development of Integration Best Practices

A key research objective is the development of best practices for integrating distributed resources into existing asset control systems, and to measure the acceptance of battery storage systems as a tool for renewable power integration. In PGE’s Proposal and in the Stipulation approved in Commission Order No. 18-290, PGE committed to aggregate and dispatch residential energy storage as a fleet. Aggregated dispatch will allow PGE to evaluate battery impact on generation services and transmission & distribution (T&D) services,[15] while also allowing the resources to be used by PGE Power Operations for generation capacity, energy resource optimization, and contingency reserves.

[15] See page 5 of Commission Order 18-290 in Docket UM 1856

Generation Services

The intent of dispatching the residential energy storage devices as a fleet is to evaluate each of the potential use cases[16] which include bulk energy and ancillary services. PGE intends to also collect learnings for localized T&D grid services, which can respond to localized controls/settings or a coordinated dispatch at the feeder/substation level. These values can be co-optimized to enhance the total potential value represented by a residential energy storage device, but only to the degree that the resource is of sufficient size to participate in delivering Bulk Energy and Ancillary Services or Distribution Capacity Deferral (PGE Power Operations dispatches in 1 MW increments). If aggregated and dispatched as a virtual power plant of 1 MW or larger, PGE will gain learnings in co-optimizing the Bulk Energy and Ancillary Services along with the localized T&D services. The dispatch and data collection plan for collecting learnings and identifying values is included as Appendix D.

T&D Services

In aggregate, fleet operation should be significant enough for grid operations to see the effects of the resource as it moves from the grid edge to distribution operations to the bulk system. Once PGE understands how best to design a controls hierarchy which co-optimizes the aggregate resource while retaining appropriate localized value for individual units, the Company will be better positioned to further incorporate residential programs into T&D planning. This represents a major learning for PGE which can also inform our efforts to value and effectively integrate other distributed energy resources (DERs) into T&D grid planning and operations.

PGE will test location-specific functions like the ability to manage distribution feeder voltage, or the ability to reliably influence distribution power flow. In understanding how reliably these devices can deliver these services, and how much impact they are able to have on the distribution system, it will help calculate what theoretical locational value may exist. PGE may then establish settings for the devices to operate based on location-specific needs while also co-optimizing grid services around them and learn to what degree those services conflict with each other or are compatible with each other. Finally, PGE will compare performance for direct-control over the storage assets versus what we anticipate performance to look like for passive-control (e.g., Time of Use) to determine which is more cost effective.

Section 4. Pilot Benefits

This section describes the pilot's benefits to the electrical system and to participating customers. PGE is currently able to model and assign value to some, but not all these benefits.

PGE will leverage the residential batteries for both distribution and generation uses cases in order to manage system costs and displace future investment in peaking plants. This pilot allows PGE to functionalize the complexity of power flowing both to and from customers before integrating and operating DERs at a larger scale. Residential energy storage will be deployed for the following use cases:

Distribution use cases:

- Localized demand response

[16] The energy storage potential use cases available to PGE are outlined in Appendix C Energy Storage Use Cases Identified in UM 1751 Order 17-118.

- Autonomous Volt/Var support

Generation use cases:

- Generation capacity
- Energy resource optimization
- Contingency reserves
- Autonomous frequency response

Customer use cases:

- Outage mitigation

4.1. Distribution Benefits

4.1(a) Localized Demand Response

Definition: Localized demand response will be employed to test the effectiveness of the batteries to influence powerflow on the distribution system for the purpose of distribution congestion relief.

Dispatch: PGE will manually dispatch ad-hoc, likely during times of peak summer and peak winter loading conditions. Dispatch will be via the aggregation platform directly to enable the capability to dispatch a selected grouping of energy storage resources to validate the expected distribution system response.

4.1(b) Autonomous Volt/VAr Support

Definition: Autonomous Volt/VAr support is a local, distribution level function in which a DER can inject VArs to support voltage. Advanced VAr management is one tool a utility can use to manage system voltage and power factor.

Dispatch: This use case is enabled, rather than dispatched. Residential batteries will include Volt/VAr support as a built-in feature that PGE can turn on and off via a central control. PGE will turn this on when appropriate and the device will provide services autonomously. This use case will be more valuable when Advanced Distribution Management System (ADMS) is in place (anticipated in 2022). PGE will test this use case pre-ADMS, and post-ADMS it will be managed by the Distribution System Operator.

4.2. Generation Benefits

4.2(a) Generation Capacity

Definition: Generation capacity adequacy (sometimes referred to as resource adequacy) is largely a planning term which refers to the amount of power generating capability needed to meet an adequacy standard (such as a loss of load probability of one day in ten years). PGE considers generation capacity value to be based on a resource's capacity contribution and the cost of an avoided new long-term capacity resource. The Pacific Northwest does not have an organized capacity market.

Dispatch: Batteries store energy and can contribute generation capacity when dispatched for this purpose, typically during peak load conditions. Day-ahead power purchasers plan for resource dispatch as well as power purchases. On the day of dispatch, the battery will be scheduled by real-time power traders. Balancing authority operations (BAO) will then dispatch the resource according to schedule.

4.2(b) Energy Resource Optimization

Definition: This use case distinguishes the scheduling of batteries to reduce power costs from PGE's long-term need to build and market procurement. Energy Resource Optimization is a unique operational use case for valuation purposes only—it describes power cost reduction.

Dispatch: Same as Generation Capacity.

4.2(c) Contingency Reserves

Definition: Contingency reserves refers to both spinning and non-spinning reserves. NERC requires that each Balancing Authority provide resources on a stand-by basis to respond to unplanned events. Qualifying resources must be able to run for 60 minutes. PGE is part of a reserve sharing program and calculates its reserves as three percent of system load plus three percent of online generation. Batteries can provide both spinning reserve (synchronized to the grid) and non-spinning reserves (not synchronized to the grid). Reserves are required per NERC standards, as well as for PGE's participation in the Energy Imbalance Market (EIM); however, they are not bid into the EIM.

Dispatch: PGE dispatches operating reserves in response to unplanned events via the BAO. The Company may integrate the batteries into GenOnSys, PGE's Distributed Energy Resource Management System (DERMS), which currently aggregates and dispatches its DSG.[17]

4.2(d) Autonomous Frequency Response (Freq/Watt)

Definition: The entire Western Electricity Coordinating Council (WECC) system needs to maintain frequency within a certain band both during normal operations and in response to a disturbance or major event. The North American Energy Reliability Corporation (NERC) requires PGE to contribute to maintaining this frequency following a major event. PGE meets this requirement by dispatching energy resources (e.g. sourcing or sinking kW from the system) to help maintain interconnection frequency within the predefined bounds in response to a system frequency deviation. Modern residential inverters can provide this function.

Dispatch: This use case is enabled, rather than dispatched. It is responsive to local monitoring and control functions.

4.3. Participant Benefits

4.3(a) Outage Mitigation

Definition: In the event of a power outage, the battery will provide power to the customer. This is a customer benefit, rather than a system benefit.

[17] More on this approach can be found on in Section 6.4 Dispatch.

Dispatch: Outage mitigation is an automatic service. The battery will sense when a local grid disruption occurs, resulting in a customer outage, and it will switch the residence over to battery power ("island"), thereby mitigating the outage.

Section 5. Customer Options

The pilot will provide ongoing incentives to any customer with a qualifying battery system, but also is making available additional offers to customers living within the Test Bed and those who are income qualified and taking part in the Energy Trust's Solar Within Reach program. These additional offers serve to drive density to study locational benefits of battery storage and understanding the needs of different types of customers who may benefit from battery storage, respectively. For a look at additional rebates, for which customers who purchase batteries may be eligible, see Appendix E.

5.1(a) Base Offering

Any customer within PGE's service territory who either has an existing qualified battery or is planning to install a new qualified battery is eligible for the base option. For these customers, PGE will operate the battery in exchange for a monthly payment of $40 if the battery is able to charge from the grid, or $20 if the battery is restricted to passive charging from PV. The monthly incentive is intended to compensate a customer for what they could potentially realize using the battery for bill management with perfect TOU optimization, RTE losses, and convenience. The customer may evaluate whether PGE's bill credit is sufficient to allow for utility operation and acceptance of this rate will be a key pilot learning. A customer may opt out of the pilot any time they choose.

PGE believes it is appropriate to have a tiered monthly incentive dependent on whether the battery can charge from the grid or is only able to receive rooftop PV. The value of battery storage to the customer from bill optimization is lower when the battery can only be charged from rooftop solar, and the value of the device to PGE is lower as well. During the winter months when the days are shorter and the Willamette Valley receives frequent cloud cover and rain, the usable energy on a day-to-day basis is less predictable and the battery may have very little energy to store and discharge for grid services during these winter peaking months. Without grid charging the batteries also cannot perform all the use cases PGE is testing, such as charging when wholesale electricity prices are low for price optimization or respond to over-frequency events.

When the pilot reaches capacity (525 batteries), PGE may develop a wait list and enroll customers to replace those that withdraw from the Pilot.

5.1(b) Test Bed Rebate

Customers living within one of the PGE Test Beds[18] are eligible for an up-front rebate in addition to the monthly bill credit. This is to encourage density on the three select substations of the Test Bed and to allow PGE to study locational T&D impacts. To encourage prompt action as well as to test the impact of varying incentive levels on uptake, PGE will employ a tiered incentive that steps down after a certain level of uptake. Among the targeted

[18] As defined by PGE Rate Schedule 13.

200 Test Bed participants, the first third will receive $3,000, the second third will receive $2,000, and the last third to enroll in the pilot will receive $1,000.

Customers receiving the up-front rebate will sign an agreement to participate in the entire pilot, or PGE has the option to require re-payment of the unamortized portion[19] of the rebate.

5.1(c) Income Qualified Rebate Coordination with Energy Trust

The Energy Trust launched an offering to provide increased incentives to income qualified homeowners in the fall of 2019 called Solar Within Reach.[20] In conjunction with that program, PGE is offering a rebate of $5,000 to any participant in that program also installing a qualified battery. PGE estimates that 25 participants may take this offer, but maintains the discretion to expand this offer to more customers if necessary.

The Energy Trust will take the lead on identifying and qualifying candidates for Solar Within Reach and ensuring that participants and installers are aware of PGE's special offering. PGE will work with Energy Trust to understand the challenges that lower income customers face in acquiring battery storage, whether it be education, incentive level, or physical attributes of the home.

PGE believes that learning about the resiliency needs of a varied customer base is important as customer adoption of distributed energy resources grows.

5.1(d) CERT and NET Volunteers

PGE will partner with Emergency Management bureaus throughout the service territory to perform outreach and give the opportunity to sign-up for the pilot to CERT and NET emergency response teams. Per the Portland Bureau of Emergency Management (PBEM)[21]:

> *Neighborhood Emergency Teams (NETs) are Portland residents trained by PBEM and Portland Fire & Rescue to provide emergency disaster assistance within their own neighborhoods. NET members are trained to save lives and property until professional responders can arrive. These volunteers are specially trained to help others without putting themselves in harm's way. NET members are:*
>
> 1. *Prepared to be self-sufficient for two weeks during any emergency.*
> 2. *Able to provide emergency assistance to their family and immediate neighbors.*
> 3. *Able to work within an emergency response team to save lives and property in their neighborhood.*
> 4. *Able to guide untrained volunteers who want to help others during a disaster.*

These volunteers may expand the direct benefits of outage mitigation to a greater number of households in the event of a major power outage. CERT and NET volunteers can also help vulnerable neighbors who would benefit from power during times of an emergency but may be less likely to be able to directly afford this themselves. A letter of support from Portland CERT is available in Appendix G.

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[19] This is calculated as the proportion of the unpaid amount when calculated over the potential length of time the customer would have been eligible to participate in the Pilot.
[20] For more information see Appendix F Solar Within Reach Overview.
[21] https://www.portlandoregon.gov/pbem/31667

Section 6. Pilot Design Detail

6.1. Pilot Size

PGE is recommending integrating 525 units for the Pilot in order to have sufficient generational capacity of 1 MW for a 4-hour period to act as a virtual power plant. This will include a target of 200 units within the test bed substations, 25 income qualified installations, and 300 units anywhere in the service territory.

Using assumptions from a Tesla Powerwall 2, it would take approximately 570 operational units to meet the minimum desired capacity of 1 MW on the darkest day of the year.[22] However, at the proposed level of 525 units PGE will be able to meet the desired 1 MW of capacity for four hours 80 percent of the year using the same assumptions as above and with historically average weather. The eventual proportion of devices restricted to solar charging (due to receipt of the Federal Solar Investment Tax Credit, or "ITC") will impact the required number of units, as batteries that can grid charge average over double the discharge capacity during Portland's rainy months.

To ensure PGE can test locational value, a concentration of devices will be required to recognize impact on the distribution system. For this reason, additional incentives will be provided to customers within the three PGE Test Beds to achieve a measurable impact on a single distribution feeder. A single residential battery system fully charged may deliver 5 kW at any given point in time, which represents about 0.05% of a distribution feeder's typical load. To have a measurable impact on a distribution feeder's performance, concentrations that affect the power flow of at least 3%, or 0.2-0.3 MW of energy storage per distribution feeder, are necessary. Anything less than this impact is lost within the margin of error, and the opportunity to explore location-specific value diminishes. Using the same math as above, to reach 0.3 MW of capacity during the lowest production solar month on a single feeder requires a minimum of 171 batteries. PGE will pursue other methods of inducing density beyond just the Test Bed, including working with new home builders who may want to include battery storage in a subdivision.

PGE will easily stay within the stipulated capital restriction of $1.5M, as there is close to no capital projected for this Pilot, and the Company has designed the Pilot to stay well within the operations and maintenance (O&M) targets set in UM 1856.

6.1(a) Market Trends

In PGE's service territory, there are approximately 150 residential battery installations and about 15,000 rooftop solar installations.[23] PGE's Test Bed currently has 407 rooftop solar installations and three homes with a battery

[22] Assuming 100% of usable energy capacity is used for a 4-hour discharge in aggregate, and we assume that we optimize for the average production in the lowest solar production month with solar size of 4.87 kW nameplate (the median residential solar installation on our system), then ITC-restricted batteries have 5.4 kWh of usable capacity on an average December day per PV Watts. If 80% of installed batteries are ITC-restricted, with the other 20% being able to charge from the grid (thus having 13.5 kWh of usable capacity), then we need 570 batteries to achieve 1MW discharge for 4 hours. The math goes as follows- Solve for n: $(0.2 * 13.5kWh / 4h + 0.8 * 5.4kWh / 4h) * n = 1000kW$

[23] PGE (2020)

installed.[24] Achieving the targets outlined above will require more than tripling the existing battery installations in PGE's territory within three years. Current market trends support these projections, with the most recent Wood Mackenzie Energy Storage Monitor forecasting a tripling of residential energy storage capacity nationwide from 2020 to 2024, as shown in Figure 1[25].

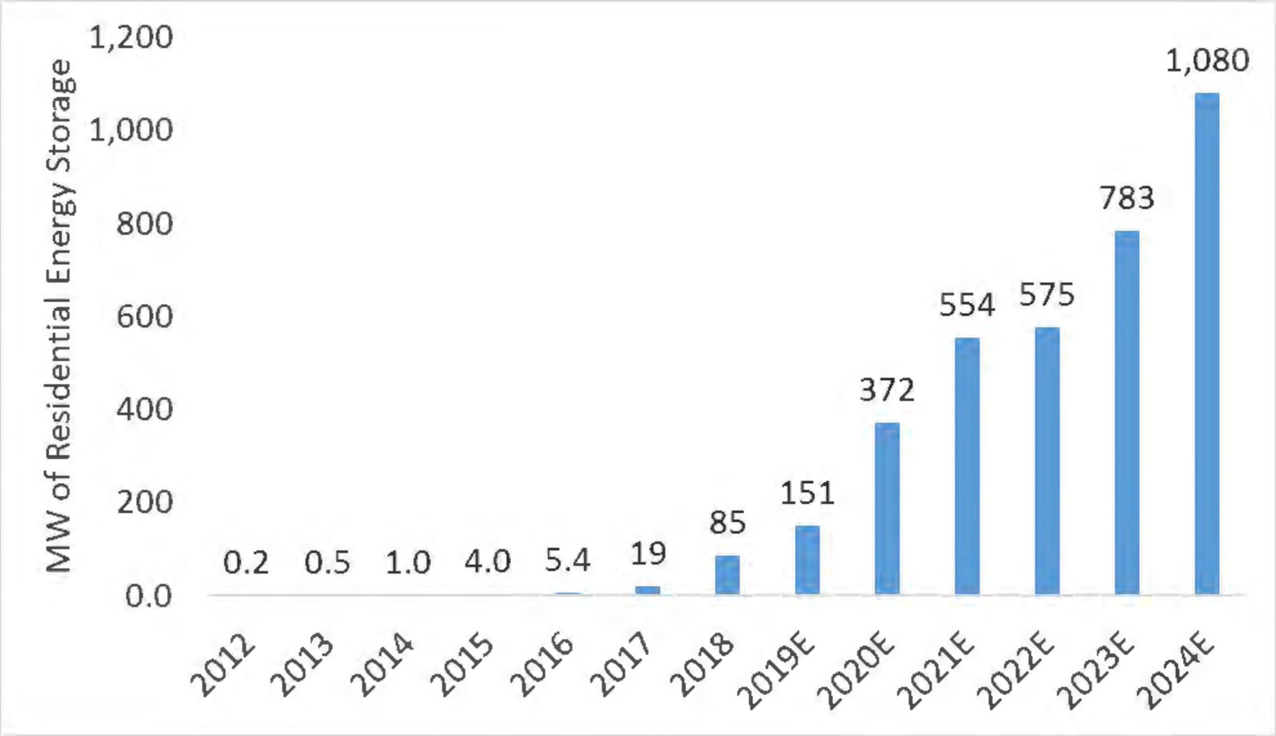

Figure 1 US Residential Energy Storage Deployment Forecast (MW)

Research by Navigant forecasting residential energy storage adoption in PGE's service territory shows similar strong projected growth, with a base case of nearly 700 batteries will be in PGE's service territory by 2023 and a high case forecast of nearly 2,500 installed batteries, as shown in Figure 2 below[26].

[24] Id.
[25] Wood Mackenzie P&R/ESA U S energy storage monitor Q 4 2019
[26] Navigant PGE DER Forecast (2019)

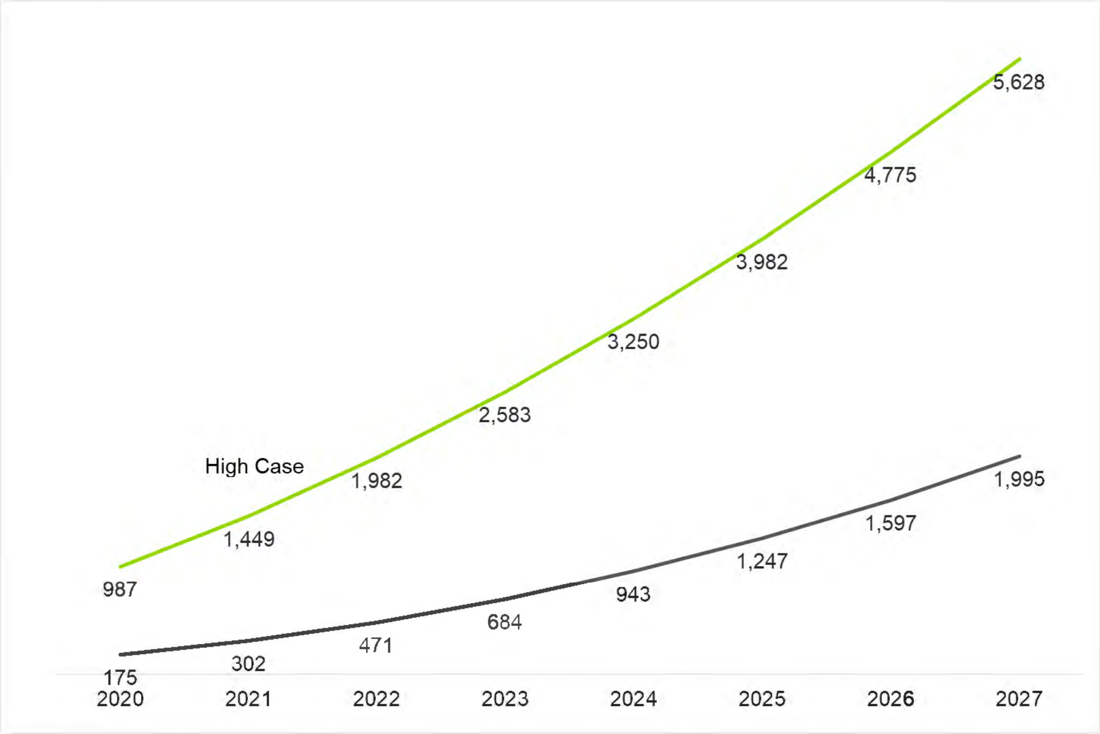

Figure 2 Navigant Residential Storage Forecasted Installations

One of the drivers of adoption considered by Navigant was the customer's value of resiliency. This may increase due to the public safety power shutoffs in California and extreme weather events in the Northeast and Southeast.

Regarding financial drivers, the Wood Mackenzie report says:

> *In the future, factors including battery price reductions, declining hardware and controls costs, product standardization and process optimization will drive system-level price declines in the residential and non-residential BTM markets. Beyond just component-cost reductions, improvements in soft costs will also be realized as the market attains further maturity and policy changes drive improvements in permitting and interconnection processes.*

Additionally, the continued decline in lithium-ion battery pack prices will aid residential storage adoption. Since 2010, the price of lithium-ion battery packs has declined over 85% from 1,183 $/kWh to 156 $/kWh in 2019.[27] Nationwide, the decline in lithium-ion battery prices resulted in a 500% increase in residential storage from 2017 to 2018. Battery prices are expected to drop below $100/kWh by 2024.[28]

PGE believes that these market trends paired with well-designed incentives and an increased awareness of resiliency among Oregonians will allow this Pilot to meet its enrollment goals. The Company conducted a market research study in January 2020[29] with 1,432 customers completing the survey. Results showed that almost half (45%) of survey respondents are familiar with battery storage systems, with 63% interested in learning more.

[27] BNEF (2019)
[28] BNEF (2019)
[29] PGE PV/Battery Survey, 2020

Twenty of the 37 customers surveyed who already have a battery system would consider allowing PGE to manage their battery charging and discharging without any mention of an incentive, while three-quarters (76%) of customers without a battery system would hypothetically consider allowing PGE to manage their battery charging and discharging without any mention of an incentive.

6.2. Enrollment and Installation Process

6.2(a) Customer Outreach & Education

PGE has asked the Energy Trust to provide a bid to partner with PGE for this pilot. The existing infrastructure for the Energy Trust's solar program and their consistently high performance on the enrollment, installation, and verification of solar systems makes them a well-suited partner[30].

Due to their available incentives, the Energy Trust installs the overwhelming majority of residential solar energy systems in PGE's service territory. Because most battery storage systems are installed in conjunction with solar, PGE believes there are opportunities to leverage the Energy Trust's solar website and solar trade allies to reach customers who may be good candidates for PGE's program.

Collateral will be developed by PGE for distribution assistance from the Energy Trust, and will include information about the pilot offers, and qualified solar trade ally contractors will be trained to discuss the offerings with potential customers.

PGE will also proactively reach out to customers that are identified as having a battery system that may be able to participate in the program, as well as customers with existing solar energy systems that may wish to add battery storage. Methods for reaching out to these customers may include direct mail, email, or phone outreach.

An important part of the Pilot is installing batteries in strategic locations to test the T&D locational value of residential battery storage systems, and as such PGE will need to perform targeted outreach among homeowners living along certain feeder lines or on specific substations. To reach these customers PGE may use direct mail outreach, email messaging, door hangers, door knocking, and community events.

As discussed previously, outreach will be performed to members of CERT and NET. The volunteer members will gain awareness of the offering through agency communications and PGE may attend volunteer meetings to present the offer and answer questions about back-up battery storage and solar systems.

[30] Per the Energy Trust Solar Electric Program – Verification Evaluation Participant Survey of 2017, 93% of surveyed participants reported being "Very Satisfied" or "Somewhat Satisfied" with their overall experience working with the Energy Trust's Solar Program.

6.2(b) Rollout Schedule

Immediately upon Pilot approval PGE will work with CERT and NET volunteers to inform them of the Pilot offering and will also allow Energy Trust to make the offer available to Solar Within Reach participants. Table 2 outlines the general outreach strategy and timing. PGE will aim to do a phased recruitment, allowing the Company to gather learnings and perform iterative improvements during the pilot.

Table 1 Outreach Overview

Location	Channel	Timing	Target
Entire Service Territory	Existing storage installations	Y1, immediately upon Pilot approval	50
	Income Qualified, Solar within Reach	Y1, immediately upon Pilot approval	25
	Customers with or without solar	Y2-Y3	250
Test Bed	Customers with solar systems, no existing storage	Y1, immediately upon Pilot approval	50
	Customers without current solar or storage	Y1, 6 months after pilot approval	50
	Customers with or without solar	Y2-Y3	100

6.2(c) Application

Any customer who wishes to install new battery storage or who has an existing device they would like to enroll in PGE's Pilot must first submit an interconnection application. This process is part of PGE's typical operations and ensures that the distribution system can safely accommodate additional DERS. After PGE approves a customer's interconnection application, they may then proceed with the storage installation and to apply for acceptance into the Pilot. PGE will attempt to streamline the Pilot application with the interconnection application to the extent possible.

Due to the limited nature of the Pilot, customers installing a storage device are not guaranteed an up-front rebate or ongoing incentive payments before receiving prior approval from PGE. Trade allies may complete and submit the application on behalf of the residential applicant, or the customer may submit it themselves. PGE will make the application available to Energy Trust solar trade allies on the Energy Trust website and on PGE's website.

PGE will respond to a customer within 10 business days of receipt of their application. If the customer does not have an approved interconnection agreement, their application will be denied. If PGE meets its enrollment targets, it may either elect to maintain a wait list and allow a customer to join in the event of Pilot attrition or confer with the OPUC to allow for additional participants.

6.2(d) Qualified Batteries

PGE will maintain a QPL for all batteries deemed appropriate to participate in this pilot. To prepare this list, PGE sent a request for information (RFI) to 13 vendors[31] requesting information about their company, product, and experience with utility programs to help PGE better understand the technical abilities and market capabilities of potential battery vendors.

Eight vendors supplied responses[32] and, after review of the responses, PGE conducted follow-up interviews with six vendors.[33] Selection criteria included accuracy of inverter metrology, ability for PGE to perform grid services with the device, ability and cost to interconnect and implement required controls and telemetry, and market presence/distribution channels in the Pacific Northwest.

PGE sought to allow a variety of battery vendors to participate in the Pilot in order to promote customer choice and to mitigate the risk of a single vendor or vendors going out of business. However, a significant hurdle to allowing any device to participate is the ability and cost to operate it. PGE opted to allow any UL certified and commercially available battery system integrated with the preferred aggregation platform to participate. At this time those devices include Pika, SolarEdge, Sonnen, SunVerge, and Tesla. PGE will execute a contractual agreement with a preferred aggregation vendor executed pending approval of this Pilot, upon which time PGE will finalize the QPL.

PGE may opt to remove a vendor from the QPL if the device is not performing to meet pilot research objectives or customer needs. Additionally, PGE may add vendors to the QPL if they meet pilot requirements and integrate into the aggregation platform.

6.2(e) Installation

PGE will utilize the existing installation network and trade ally vetting processes currently in use by the Energy Trust's solar program. This will serve to streamline the process for customers wishing to utilize both Energy Trust solar incentives and this program's battery offerings, as well as reduce overhead costs and redundancies. Customers will be able to choose any qualified Energy Trust Solar trade ally, receive competitive bids, and coordinate installation of battery energy systems.

Qualified trade allies are a powerful tool that PGE will leverage for customer education and enrollment. PGE and Energy Trust will collaborate to educate contractors about the pilot through in-person educational sessions and written manuals. Contractors will also be provided with collateral to help them talk customers through the pilot options and enrollment.

Once the customer has agreed to move forward with a battery system and an installer, and has been approved through PGE's interconnection process, the trade ally contractor or customer will submit an application for the battery pilot rebate and/or monthly bill credit. After PGE approves the application, the contractor will source the equipment through typical channels and complete the system installation. After installation is complete and PGE

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[31] The RFI was sent to Sonnen, Panasonic, Pika, SolarEdge, Simpliphi, Outback, Tesla, ElectrIQ, Sunrun, Enphase, Sunverge, Eguana Technologies, E-Gear.

[32] Responses were received from ElectrIQ, Outback, Pika, SolarEdge, Sonnen, Sunrun, Sunverge, and Tesla.

[33] PGE conducted second interviews with SunRun, Sunverge, Sonnen, Pika, Tesla, and SolarEdge.

is able to communicate with the device, monthly incentive payments for the provided grid services will commence and the installer will be reimbursed for any applicable rebate.

All battery storage systems must be installed according to National Fire Protection Association (NFPA), state and local codes, permitting laws, as well as manufacturers installation requirements. The Energy Trust will audit some or all installations as part of the solar program verification to ensure that installations meet the requirements of the pilot rules. PGE will collaborate with the Energy Trust to include additional inspection items on the verification checklist. PGE may request proof of electrical permit for any installation.

6.2(f) "Grandfathered" Battery Installations

Pre-existing qualified batteries must undergo verification prior to enrollment in the pilot. An Energy Trust solar trade ally, PGE employee, or third-party contractor will perform an onsite visit to verify any pre-existing qualified batteries that wishes to interconnect with PGE. The verifier will ensure that the battery is compliant with all relevant state and local codes as well as NFPA requirements. If the verifier determines that the battery is not code-compliant or that PGE's operation of the battery would be unsafe, PGE may allow the customer to correct the issue and re-apply for the pilot. As part of this verification, the PGE interconnection group must also evaluate the installation to ensure distribution system integrity.

6.3. Energy Measurement & Metering

Upon Pilot launch PGE will bill customers from their utility revenue meter and will not adjust customer bills as a result of the battery's operations. When PGE is utilizing a customer-sited battery for grid services whose home is on a TOU rate schedule, there is the chance that PGE may cause a customer's bill to be higher or lower than it would without participation in PGE's energy storage pilot. The impact is likely to be a net benefit to the customer, as PGE is most likely to perform grid services that are in close alignment with the behavior TOU rate structures are trying to encourage. A second consideration is the impact of RTE losses inherent in the charging and discharging of battery energy storage. The inverter round-trip efficiency is estimated to be about 90%[34], which would amount to a monthly electricity cost for RTE losses of $2.73. The customer's monthly incentive payment is intended to fully cover the potential impact of TOU as well as the cost of RTE losses.

Upon Pilot launch PGE will perform testing on the accuracy of the measurement devices using the test batteries and will calculate the TOU and RTE impacts to understand actual bill impacts for pilot participants. After understanding the potential bill impacts and the accuracy of the inverter measurement devices, PGE will determine whether it would be feasible and/or advisable to perform the IT integrations necessary to adjust customer bills based on TOU and RTE either for the remainder of this pilot or any subsequent program.

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[34] Tesla Powerwall references a 90% round-trip efficiency (AC to AC) for a newly installed battery operating in ideal conditions (charge/discharge rate at 66% of nameplate capacity in 25 DEGC ambient). Actual efficiency is expected to vary based on ambient temperature, charge/discharge rate, and age of the asset. As part of the pilot PGE will study and assess actual RTE efficiencies installed in customer homes.
https://www.tesla.com/sites/default/files/pdfs/powerwall/Powerwall%202_AC_Datasheet_en_northamerica.pdf

6.4. Dispatch

In PGE's UM 1856 proposal and in the approved Stipulation, PGE committed to aggregate and dispatch residential energy storage as a fleet.[35] After pilot approval, PGE will work to integrate the battery systems into PGE's Power Operations, but may initially launch the pilot with dispatch occurring through the aggregation platform's cloud software.

The plan for Power Operations integration uses the GenOnSys platform, a PGE custom-built distributed energy management system that currently controls over 115 MW of distributed, customer-sited back-up generators, and PGE's 5 MW battery, the Salem Smart Power Center. This platform will also dispatch the other commercial and utility scale battery storage projects PGE is implementing through UM 1856.

GenOnSys can be connected via Application Programming Interface (API) to the aggregation vendor, that will communicate with the clouds of each battery vendor, who in turn control the dispatch of the individual systems. This potential architecture is shown in figure 7 below.

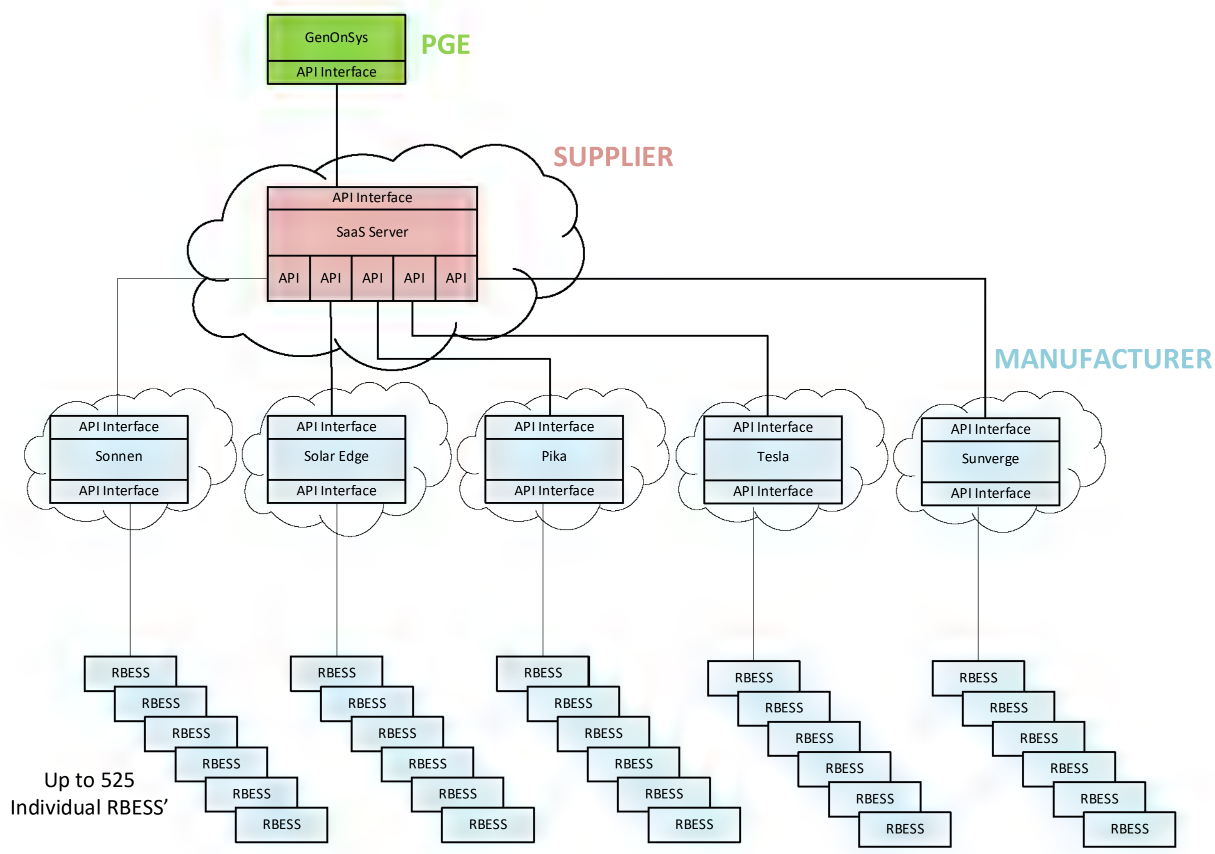

Figure 3 Proposed Dispatch Architecture

Lessons learned from the commercial implementation will provide insights for incorporating the residential units into a "virtual power plant" platform, as a means for dispatching these resources. PGE will be able to not only dispatch the energy storage systems, but to also aggregate them along with existing demand response (DR)

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[35] Docket UM 1856, Order No. 18-290 at 5.

resources. Dispatching energy storage and DR resources together can enhance the value of aggregated resources by increasing the total aggregate resource size.

PGE power operations dispatches resources in 1MW increments and would not be able to use their regular scheduling tools when the available capacity of the residential battery devices is less than 1MW. However; this does not mean that PGE will be unable to test the viability of these residential energy storage resources to provide grid services. One option for evaluating the aggregate residential energy storage resources and their effectiveness in providing grid services can be tested by incorporating them alongside the larger UM 1856 batteries for scheduling and dispatch. This option could automatically initiate dispatch of the aggregate residential energy storage resource (regardless of size) any time PGE power operations calls on a larger UM 1856 battery to provide grid services. The aggregate resource will also be available to be dispatched manually within GenOnSys, or within the aggregation platform utility management portal.

6.5. Battery Operation

PGE will operate the battery for the use cases outlined in Section 4. Customers whose batteries are restricted to solely charge from PV (due to receipt of the ITC) will not be able to perform all use cases, due to the inability to receive power from the grid. PGE will hire a third-party research firm to develop an evaluation and dispatch plan that will ensure that PGE operates the batteries in a manner that will yield data appropriate for back-end evaluation. Appendix D provides a summary of the RFP PGE plans to issue for this dispatch plan.

PGE will retain full operation and management of participating batteries, overriding any vendor bill management programming (this refers to factory pre-settings designed to optimize battery charging for the utility's TOU rate schedule). In the event of a power outage, the battery will autonomously island to provide power to the home. Batteries will remain fully charged on weekends and holidays, as well as during periods of inclement weather. For the purposes of this pilot, PGE defines inclement weather as anytime PGE's Business Continuity & Emergency Management puts emergency operators on standby.

The customer may override PGE's control of operations up to 10 times per calendar year for a period of 24 hours to allow the battery to remain fully charged. Customers who attempt to override PGE's operation more than 10 times will have their request denied and may instead elect to drop out of the pilot.

A key aspect of the pilot is testing optimal communications of customer-owned assets, including balancing cost, complexity, and reliability. PGE expects that many batteries enrolled in the program will have the ability to utilize LTE cellular data in addition to customer-managed wireless or ethernet internet. PGE plans to employ multi-modal automated reminders (email and SMS) to urge participants to re-connect their devices to the internet. The automated reminders will be sent out if a device is offline for at least 24 hours. Customers that struggle to keep their device online or whose internet connection is inadequate may be offered LTE cellular data control at PGE's discretion. Customers participating as part of the Solar Within Reach income qualified path or customers whose battery is strategically important for locational or other reasons will be given higher prioritization when considering devices to receive PGE-funded communications.

If a customer does not restore connectivity within 30 days PGE has the option to remove the customer from the pilot and they will no longer receive bill credits. If the customer resolves the issue at a future date, they may opt back into the pilot, or be placed on the waiting list if the pilot is fully subscribed. PGE may also move the customer's device to LTE cellular data, for batteries with the proper hardware.

6.6. Risk Management

The desire to minimize risk has been at the forefront of PGE's design choices for this pilot, balanced with the optimal design to maximize learnings. The identified risks and PGE's mitigation strategies are outlined in Table 2 below.

Table 2. Risk Mitigation Plan

Category	Potential Risk	Mitigation Strategies
Liability	• Personal injury • Property damage	• Require high quality installation partners, vetted through Energy Trust solar trade ally program • Abide by safe operating guidelines within warranty guidelines • Use proven technologies with certifications & listings • Continuous electronic monitoring of battery system health (ability to shut off battery if unsafe conditions are detected) • PGE will use test batteries installed on PGE property to test all use cases prior to commencing customer installations.
	• PGE employee safety	• Additional training and safety checks implemented in Q4 2019 • Employees will be trained with test batteries
	• Cyber-security	• Firewalls and infrastructure of GenOnSys make risk of a bad actor accessing PGEs' systems low • Risk of bad actor accessing individual customer batteries through unsecured customer Wi-Fi. Low value target, low likelihood to harm energy system or customer through misuse on the individual level. • Shift legal risks and liabilities to vendors and customers by contracting and terms & conditions
Program	• Low enrollment • Customers drop-out of pilot • Risk of incurring costs without hitting enrollment targets and/or delivering learnings	Low enrollment could lead to insufficient aggregated capacity and limited learnings. Should PGE struggle to get customers to sign-up, mitigation efforts within the stipulated agreement include: • Increase the customer-owned monthly payments or up-front rebate amount • Allocate sufficient resources to market the pilot • When customers drop out a new customer will be allowed to take their place to keep the minimum capacity of the pilot. A wait list will be maintained, and new customers may be identified through the interconnection process • Keep costs low, lower exposure if targets are not hit

		• Spend & enrollment milestones over 3 years of pilot recruitment, annually assess health & performance
	• High enrollment	A waiting list will be maintained in the event of high demand. The project is capped to avoid over-spending. Should the parties agree that an expansion is in order, the stipulation can be re-opened for a second phase of the pilot.
	• Poor customer value proposition • Risk of adverse customer experience • Risk of misalignment with other products and services • Introduction of new TOU rate	• Revised pilot duration and structure is more customer friendly • Regular customer engagement for participants and non-participants to understand the hurdles and Customer Value Proposition of the pilot, inform future program design • Any TOU rate development should ensure that the impacts on battery storage are thought through. A TOU rate structure could be a viable off-ramp for battery storage, but for limited use cases • Concept testing prior to launch • Small scale R&D-type pilot, learnings will inform future program development that impacts more customers
Product	• Batteries degrade faster than anticipated • Bad battery efficiency	• PGE will operate the batteries within warranty guidelines • Vendors guarantee energy retention as part of their warranty • All batteries are customer-owned, no risk of a stranded asset if a device fails before the estimated useful life • While the current pilot proposes a flat incentive for participation, future programs can pay a variable rate for actual capacity delivered
	• Vendor goes out of business	• Vendors allowed to participate in the Pilot have been vetted and all are backed by larger companies or have very healthy, robust balance sheets. • Should they still go out of business it is highly probable that another vendor will take over the cloud integration of those assets • Should no other manufacturer pick up the customers, a last resort PGE could do direct API integration with individual devices • If a vendor cloud is no longer supported PGE can cease paying monthly incentives to that customer, no stranded asset • Ensure that there are a number of equipment repair people throughout the PGE service territory (that the product is not so unique or proprietary that only one person can fix)
	• Cannot communicate with batteries	• Automated reports that can send a customer reminder when battery is not communicating

		• If battery is not connected for a month the customer will be removed from the pilot • Option for LTE cellular communications for many devices
Financial	• Higher than anticipated costs	• Incremental pricing strategy will be employed whenever possible rather than large up-front costs
	• Customer non-payment	• Ongoing customer payments have been removed from the pilot structure

6.7. Budget

Pilot capital costs fall within the stipulated maximum of $1.5M overnight capital. The only portion of the Pilot that qualifies as a capital expense at this time is the purchase of test batteries that will be installed in PGE locations for training and dispatch testing purposes at an estimated cost of $33,000 (five-year NPV of $40,000).

The O&M costs outlined below are the costs that PGE will include in its deferral request. Per the stipulation of UM 1856[36], evaluation costs are not included in this budget. The costs specific to operating this residential pilot will be included as part of the deferral, though in accordance with the stipulation no administrative costs of operating the entire portfolio of battery storage projects are requested.

PGE will stay within the guidelines of $5.7M NPV of revenue requirement and a year one revenue requirement of $700k. O&M costs are comprised of incentives (monthly + Test Bed and income qualified upfront rebates), program operations (Energy Trust contract, PGE program management, customer outreach), and the cost to dispatch the batteries as a fleet.

The table below reports program costs on a Net Present Value basis over the five-year pilot life. This is the amount (excluding the capital costs) that will be requested in the deferral application.

Table 3 Pilot Budget: five-year NPV, 2020$

Budget Item	Rounded ,000
Incentives	**$1,290**
Monthly incentives; Grid Charging	$547
Monthly incentives; PV Restricted	$272
Test Bed Rebates	$362
Income Qualified Rebates	$109
Program costs	**$926**
PGE Program Manager	$376
PGE Customer Outreach	$61
ETO implementation	$423
Energy losses	$66
Aggregation & Dispatch	**$625**
Aggregation platform	$351
GenOnSys API Integration	$113
Vendor communications fee	$162
Operations Dispatch Plan	$33
Total Requested Deferral	**$2,841**
UM 1856 O&M Budget	*$5,700*
Capital costs to utility	**$40**
Test batteries	$40
UM 1856 Capital Budget	*$1,500*
Total Budget	**$2,881**

[36] UM 1856 Partial Stipulation

Section 7. Evaluation

Under the stipulation in Order 18-290, PGE must file an annual compliance evaluation report and comprehensive evaluations in years 3, 6, and 10 of the pilot—looking at all five of the battery pilots approved under the order. PGE proposes to file a comprehensive evaluation in year 3 after the recruiting phase is complete, and the final evaluation in year 6, after the pilot is complete. As previously noted,[37] PGE has sought the assistance of third-party experts to develop best-practices for evaluation prior to launching the study, which is intended to ensure that the data provided to the third-party vendor will yield meaningful results. Table 4, below, outlines the evaluation schedule.

Table 4 Evaluation Schedule

Year	Activity	EOY Projected Capacity
1	Pilot Launch	175 customers, between 0.2MW-0.6MW for 4 hours
	Year 1 Recruitment Activities	
	Compliance Evaluation Report	
2	Year 2 Recruitment Activities	350 customers, between 0.4MW-0.2MW for 4 hours
	Compliance Evaluation Report	
3	Final Year of Recruitment	Full subscription: 525 customers, between 0.57MW-1.77MW for 4 hours
	Comprehensive Mid-Pilot Evaluation	
4	Recruitment closed, pilot operations	
	Compliance Evaluation Report	
5	Final Year of pilot Operations	
	Comprehensive Final-Pilot Evaluation	

7.1. Comprehensive Reports

The comprehensive mid-pilot and final evaluation reports will be completed by a third-party, and PGE will issue a competitive request for proposal (RFP). The evaluation should conform with established industry standards (e.g., the Department of Energy's Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage).[38] This protocol outlines how to perform baseline and duty cycle tests to ensure a battery storage system can perform at the required response times for various grid services. PGE will require selected evaluators to note and justify any deviations from this protocol.

As noted in Sections 4.2 and 6.4, PGE will use GenOnSys to integrate all the batteries. GenOnSys as well as the aggregation platform will capture and provide historical access to all the relevant data about inverter charge/discharge times, state of charge, and current and voltage levels.

The comprehensive reports will seek to answer the questions laid out in Section 3, and to quantify the IRP values of any tested use cases that PGE was able to execute.

[37] See section 6.5 Battery Operation.
[38] https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8274603

More details on the evaluation plan are available in PGE's January 25, 2019 Addendum filed in UM 1856.[39]

7.2. Annual Compliance Reports

Between comprehensive filings PGE will complete annual compliance filings. Compliance evaluation reports will be prepared by internal PGE resources, and will include qualitative and quantitative updates on program progress, including:

- Participation metrics – customers recruited, enrolled, who have dropped out, etc.
- Demographic profile of participating customers
- Budget update – projected and actual spend
- Available capacity
- Any in-house modeling results that have been conducted
- Any in-house calculations on RTE losses, actual TOU billing impacts
- Integration and dispatch methods, what's going well and what needs improvement
- Communications metrics – wifi uptime, LTE metrics, lessons learned
- Results of any customer and/or installer surveys and/or interviews

Below is a table of the detailed learnings that PGE committed to studying through this pilot in its compliance filing, along with the learnings hoped to gain and the method for achieving the learning.

Table 5 Evaluation Risk Management Plan

Risks	Learnings	Method
Risks of Personal Injury and Property Damage	Document issues in installation, maintenance, and decommissioning of units, as well as resolution strategy.	Internal project tracking; stakeholder interviews
Risk of Power Quality or Reliability Impacts	Capture incidence and trajectory of issues to inform PGE on what to expect from systems in the field and understand what level of support needed to ensure power quality is appropriately maintained.	Data historian for management system (GenOnSys) made available to evaluator

Integration Risk	• Can be both infrastructural barriers and software integration issues:
	  ◦ (Power systems side) PGE will continue to develop expertise in performing hosting capacity assessments as-needed to support pilot deployment.
	  ◦ (Communications) PGE will monitor communications uptime through its management platform
	  ◦ (Software) What kind of integrations are required between management system at
		• (Hosting capacity): captured in project documentation and stakeholder interviews.
		• Communications downtime monitored through PGE's management platform and recorded in data historian.
		• Software integration issues documented as necessary.

[39] UM 1856, Addendum to PGE's Residential Storage Pilot, filed Jan. 25, 2019, at 16-18, https://edocs.puc.state.or.us/efdocs/HAD/um1856had123254.pdf.

	customer site and central control system? In the course of sustained operations, what are the relative firmware upgrades or updates to relevant APIs? • PGE will gain applicable learnings around smart inverter settings for customer-connected devices and how these can affect hosting capacity.	
Risk of Inopportune Timing	How does deployment timeline relate to customer and/or system needs, and what are the implications if exogenous drivers occur during the pilot timeframe? (E.g., additional rebates or community initiatives, or large concentrations through new construction).	PGE will monitor these events and document in the process evaluation.
Risk of Low/High Enrollment	Need a representative sample to the extent possible to ensure enough diversity of load profiles to understand various use cases. In addition, PGE is interested in determining what tools are effective (or not) at marketing energy storage to residential customers? How does the ownership model affect participation, decision making to enroll, and satisfaction?	Process evaluation will review marketing materials, benchmark similar programs, conduct stakeholder interviews, and include customer surveys.
Risk of Partner Failure	By requiring adherence to open communications protocols, PGE hopes to mitigate risk due to vendor changeout in a quickly evolving market. PGE will assess performance of hardware, software, aggregations, and O&M vendors contracted through the pilot.	Conduct post-failure analysis to understand cause of failure (for cases when vendors fail to perform duties). Also through stakeholder interviews with key program staff at PGE and with implementation partners.
Risk of Supply Chain Failure	PGE will seek to engage early with vendors to plan deployment and secure delivery guarantees. PGE will pursue alternate vendors as appropriate if supply chain problems exist. Learnings will inform program planning assumptions for future offerings.	Reasons for delays will be recorded and mitigated where possible. Stakeholder interviews will capture issues and recommend strategies for mitigation on wider rollout.

Appendices

A. EPRI StorageVET Modeling

StorageVET®[40] is a dispatch modeling software that uses hourly or sub-hourly value streams for different services and optimizes a simulated dispatch of a battery according to its technical specifications and limitations such that the battery creates the highest amount of revenue. The concept of providing multiple valuable services, sometimes at the same time, via battery charging and discharging is known as "value stacking." The provided value streams can either be comprised of projected future values or historical values, depending on the goal of the analysis. If a use-case is deemed not feasible to implement, StorageVET® has the option to ignore it and the value stream(s) associated with it.

In addition to value streams for various services, the model considers local and system-wide load and generation characteristics, also on the hourly or sub-hourly level. This allows StorageVET® to optimize for certain services such as renewables firming, load peak shaving, or system upgrade deferral, if the value is high enough and if implementation is feasible.

For comparison with potential customer benefits, StorageVET® also accepts basic tariff structures based on flat demand charges, flat energy charges, time-of-use, and day of the week. Using a customer's hourly or sub-hourly load shape, StorageVET® can calculate the value of bill management services for customers. As tariff structures evolve, this can serve as an alternative competitive baseline for the value that behind-the-meter storage can provide to the system.

A key component to PGE's evaluation is the use of the EPRI StorageVet modeling tool. The StorageVet model is a publicly available, open-source energy storage valuation tool that has been used nationally and by the California Public Utilities Commission. StorageVet's development was partially funded by the California Energy Commission. It functions as a price-taker model (values are given to it) and can be run to co-optimize benefits, evaluate hourly data and benefits, and evaluate location-specific benefits. These capabilities found in StorageVet addressed Staff's concerns regarding the shortcomings of PGE's originally proposed approach. Based on the information provided by PGE, a conversation with PGE staff on March 15, 2019, and additional supporting materials provided by PGE, it appears that the StorageVet model should allow PGE to effectively estimate the energy storage benefits required by Commission Order Nos. 17-118 and 17-375.[41]

[40] All simulations are based on comma-separated value (CSV) input files, and StorageVET® is open-source, public, and coded in Python, which means that simulation set-up and their results are transparent and repeatable by any party.
[41] https://edocs.puc.state.or.us/efdocs/HAC/um1856hac151859.pdf

B. Economic Benefit of Using Battery on Schedule 7-TOU

Rate Assumptions

The rates for on-peak, mid-peak, and off-peak in Schedule 7, inclusive of volumetric charges in cents per kWh, are

- On-peak high price periods: 19.67
- Mid-peak price periods: 14.34
- Off-peak, low price periods: 3.406

Price differentials:

- H to L: 16.264
- M to L: 10.934
- H to M: 5.33

These are the prices for use below 1000 kWh, prices above 1000 kWh are 0.722 cents higher in all price periods so the price differentials do not change. There is a slight effect because of conversion losses during charging and discharging, but this analysis will consider only the prices above.

Additional Assumptions

- The battery storage specification is 13.5 kWh[42]
- Assume 80% of energy is available for frequent cycling = 10.8 kWh
- Charge efficiency 94.86%, discharge efficiency 94.86%, based off a nominal 90% round-trip efficiency (RTE, AC-AC)
- Cycle five days per week, discharge on-peak, charge during off-peak[43]
- Assume the full 80% capacity is charged and discharged during those five days

Simple Benefit Calculation

- Avoided purchase during discharge = 10.8*0.948*0.1967 = $2.0139 per day
- Cost to charge = 10.8/0.948*0.03406 = $0.3880 per day
- Typical number of days in a year with on-peak TOU rates = 254 days
- Average monthly benefit = ($2.0139 - $0.3880) * 254 days / 12 months = $34.47/month

Solar + Storage, ITC-Limited Operation

When upgrading a solar system to a solar + storage system and applying the ITC to the battery, the battery is only allowed to charge from the solar panels and shall not charge from the grid. This limits the time-shifting abilities of the battery, and during the winter months, greatly reduces the battery's capacity in general.

[42] For a Tesla Powerwall 2.

[43] A sixth cycle on cycle on Saturday would add additional benefit, but this is not assumed because 1) desire to minimize cycles to preserve battery energy capacity, and 2) assuming discharge of all energy on-peak is optimistic during summer season, thus we assume these to simplifications in modeling create a net zero impact.

Using the National Renewable Energy Laboratory's (NREL) PVWatts tool, an hourly solar panel electricity generation profile over the course of a year is generated and used to determine the day-to-day energy time shifting abilities of a battery. From this data we can determine the incremental value of upgrading from solar to a solar + storage system.

Further Assumptions

- 14% general losses on PV generation
- 96% efficiency on PV inverter
- Solar sizing is a median-sized residential solar installation of 4.87 kW.
- All solar generation goes into charging the battery until it reaches full charge
- Battery does not charge during peak hours when solar is generating[44]
- Excess solar generation not used to charge the battery is assumed to be during mid-peak hours[45]
- All solar and storage energy is assumed to be consumed by residential load (i.e. no net metering credits to manage)[46]

ITC-Limited Operation Incremental Value

As the base case, the yearly savings for a customer with solar under the above assumptions, on Schedule 7 prices and hours is $713.21/year. This value is an average over 6 weather zones across the 3 Test Beds using PVWatts' hourly generation profile.

The incremental value is calculated using the assumptions above as well as the assumptions for the simple benefit case. 5 days a week (excluding holidays), the battery is charged using solar, then discharged to 80% DoD during peak times. The yearly savings from the battery's time shifting is added to any savings due to excess generation that occurred once the battery was fully charged. The total yearly savings under this strategy are $780.81/year, which gives an incremental value of $67.60/year, or $5.63/month.

Solar + Storage, Unrestricted Battery Operation

When the storage is not restricted by the ITC, the battery may charge from the grid when there is insufficient solar to charge the battery. To maximize savings, the customer would ideally get this energy off-peak and discharge on-peak, though this requires perfect foresight to do. The savings from on-peak battery discharge from both solar and off-peak energy is added to the savings from any excess solar generation on particularly sunny days to get the yearly value of unrestricted battery operation.

This yearly value given the battery size and solar installation size above is $1,005.94/year. This gives an incremental value of $292.74/year, or $24.40/month.

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[44] If a customer is only using solar+storage for bill management, they actually lose benefit due to efficiency losses by charging the battery during peak time.

[45] Mid-peak generation accounts for approximately 71% of solar generation on Schedule 7 hours.

[46] This assumption may not hold true during times in the summer when mid-day solar generation is high, especially if the weather is clear and mild, or other scenarios. However, net metering with Schedule 7 is subject to many uncertainties, so these considerations are left out of the analysis.

Solar + Storage Incremental Value Calculation

The following symbols will be used:

- P_{PV_i} = Power generated by solar, in kW, at timestep i.
- E_{Batt_Max} = Max energy capacity of the battery (in this case 10.8)
- ε_{Batt} = Battery efficiency, expressed as nominal AC-AC RTE (in this case 0.9)
- R_{On} = On-peak energy rate per Schedule 7
- R_{Mid} = Mid-peak energy rate per Schedule 7
- R_{Off} = Off-peak energy rate per Schedule 7
- $\{R_{On}, R_{Mid}, R_{Off}\}$ will be used to express that each rate will be applied during the applicable hours to a time-varying series of values, such as P_{PV}.

(a) Base Case – Solar Only

An 8760 PV generation profile is generated for 6 weather measurement zones within the 3 Test Beds using NREL PVWatts. All the settings are at default, with 14% general losses due to shading, dust, availability, etc., and a DC-AC inverter efficiency of 96%. The profile is generated for a 1 kW solar installation and a 1 kW inverter, and then scaled up to the solar installation under analysis – for this appendix, it is 4.87 kW. This is called the "Scaled 8760."

The yearly value of the solar generation, then, is a sum of the hourly generation profile of the Scaled 8760 multiplied by the applicable rates at each date and time[47], as below:

$$Solar\ Value = \sum_{i=1}^{8760} P_{PV\_i} * \{R_{On}, R_{Mid} R_{Off}\}$$

The generation profile is on an hourly timescale, so ignoring possible sub-hourly events like sudden cloud cover, any power at some time P_{PV_i} can assumed to be equivalent to the energy generated during that hour.

This analysis is repeated for each of the 6 profiles and an average is taken for a final yearly value of $713.21 / year.

(b) First Case – Solar + Storage, ITC Constrained Operation

The generation of the Scaled 8760 is broken down into days and summed up to give a profile of the daily energy generated by the solar. For weekdays, when there is an on-peak period, the battery charges only from solar energy, with efficiency losses taken into account. For any given weekday the battery charges to some state of energy:

$$SOE_{Batt} = \begin{cases} E_{Batt\_Max}, E_{PV} \geq \dfrac{E_{Batt\_Max}}{\sqrt{\varepsilon_{Batt}}} \\ E_{PV} * \sqrt{\varepsilon_{Batt}}, E_{PV} < \dfrac{E_{Batt\_Max}}{\sqrt{\varepsilon_{Batt}}} \end{cases}$$

[47] The results of this analysis will be slightly different depending on the choice of year. A PVWatts generation profile assumes a start date of January 1st, but the choice of year will affect when the weekends and certain holidays occur, which could change the value slightly in either direction. This analysis assumes 2020 as the year.

Where E_{PV} in this equation is the total energy generated by the solar panels that day. The value from the battery is in shifting this energy to the on-peak period (assuming the solar generation was during off- and mid-peak times). In addition, on some days, the PV will generate more energy than the battery can use for charging, and this excess solar goes directly into reducing customer load or exporting to the grid via net metering. Net metering is not considered for this analysis. This excess generation is assumed to be taking place during the mid-peak, as that comprises the majority of PV generation. The value is calculated as:

$$Value = \sqrt{\varepsilon_{Batt}} * SOE_{Batt} * R_{On} + (E_{PV} - \frac{SOE_{Batt}}{\sqrt{\varepsilon_{Batt}}}) * R_{Mid}$$

Since the battery does not charge on weekends or holidays, all solar generation is used directly for customer load reduction, which is assumed to be mid-peak during Saturday and off-peak during Sunday. Due to the primitive nature of this value calculation, on-peak solar is not taken into account. We adjust for that by calculating the total amount of on-peak generation and consider a mid- to on-peak shift with the following formula:

$$Added\ Value = E_{PV-On} * (R_{On} - R_{Mid})$$

Where $E_{PV\text{-}On}$ is the on-peak solar generation for the year.

Furthermore, during days where the battery can't fully charge in a 24 hour period, we can assume that the battery is taking some energy that the solar generates during peak-time, so we have to adjust this further to avoid double-dipping in the Added Value number. Most of the days when the battery doesn't fully charge is during the months of Jan-Mar and Oct-Dec – mostly winter months. So, the on-peak generation of the winter is calculated based on the TOU profile and we can make the following adjustment:

$$Double\ Dip\ Adj = E_{PV-On-Winter} * \varepsilon_{Batt} * (R_{On} - R_{Mid})$$

Where $E_{PV\text{-}On\text{-}Winter}$ is the on-peak solar generation for the year during the winter season. The battery efficiency component compensates for energy lost to heat charging and discharging the battery that would otherwise be exported by the solar panels.

Summing the Value calculation for every day of the year and averaging all the equations over the 6 weather zones, we get a final incremental value calculation of:

$$Incremental\ Value = Value + (Added\ Value - \ Double\ Dip\ Adj) - Solar\ Value$$

This value is $67.60 / year for the parameters used in this analysis.

(c) Second Case – Solar + Storage, Unconstrained Operation

When operated unconstrained, a battery is able to get energy from the grid during off-peak hours and discharge during on-peak hours. This changes the weekday value calculation to:

$$Value = \sqrt{\varepsilon_{Batt}} * SOE_{Batt-PV} * R_{On} + \varepsilon_{Batt} * SOE_{Batt-Grid} * (R_{On} - R_{Off}) + (E_{PV} - \frac{SOE_{Batt}}{\sqrt{\varepsilon_{Batt}}}) R_{Mid}$$

Where SOE_{Batt} splits into two parts: $SOE_{Batt\text{-}PV}$, which is the portion of a battery's charge that comes from PV generation; and $SOE_{Batt\text{-}Grid}$, which is the portion of a battery's charge that comes from the grid. During a weekday, the following relation is satisfied:

$$SOE_{Batt-PV} + SOE_{Batt-Grid} = E_{Batt\_Max}$$

The other equations remain the same to calculate the Incremental Value over the 6 weather zones:

$$Added\ Value = E_{PV-On} * (R_{On} - R_{Mid})$$

$$Double\ Dip\ Adj = E_{PV-On-Winter} * \varepsilon_{Batt} * (R_{On} - R_{Mid})$$

$$Incremental\ Value = Value + (Added\ Value -\ Double\ Dip\ Adj) - Solar\ Value$$

This value is $292.74 / year for the parameters used in this analysis.

C. Energy Storage Use Cases Identified in UM 1751 Order 17-118

Category	Service	Value
Bulk Energy	Capacity or Resource Adequacy	The ESS is dispatched during peak demand events to supply energy and shave peak energy demand. The ESS reduces the need for new peaking power plants.
	Energy arbitrage	Trading in the wholesale energy markets by buying energy during low-price periods and selling it during high-price periods.
Ancillary Services	Regulation	An ESS operator responds to an area control error in order to provide a corrective response to all or a segment portion of a control area.
	Load Following	Regulation of the power output of an ESS within a prescribed area in response to changes in system frequency, tie line loading, or the relation of these to each other, so as to maintain the scheduled system frequency and/or established interchange with other areas within predetermined limits.
	Spin/Non-spin Reserve	Spinning reserve represents capacity that is online and capable of synchronizing to the grid within 10 minutes. Non-spin reserve is offline generation capable of being brought onto the grid and synchronized to it within 30 minutes.
	Voltage Support	Voltage support consists of providing reactive power onto the grid in order to maintain a desired voltage level.
	Black Start Service	Black start service is the ability of a generating unit to start without an outside electrical supply. Black start service is necessary to help ensure the reliable restoration of the grid following a blackout.
Transmission Services	Transmission Congestion Relief	Use of an ESS to store energy when the transmission system is uncongested and provide relief during hours of high congestion.
	Transmission Upgrade Deferral	Use of an ESS to reduce loading on a specific portion of the transmission system, thus delaying the need to upgrade the transmission system to accommodate load growth or regulate voltage or avoiding the purchase of additional transmission rights from third-party transmission providers.
Distribution Services	Distribution Upgrade Deferral	Use of an ESS to reduce loading on a specific portion of the distribution system, thus delaying the need to upgrade the distribution system to accommodate load growth or regulate voltage.
	Volt-VAR Control	In electric power transmission and distribution, volt-ampere reactive (VAR) is a unit used to measure reactive power in an A.C electric power system. VAR control manages the reactive power, usually attempting to get a power factor near unity (1).

	Outage Mitigation	Outage mitigation refers to the use of an ESS to reduce or eliminate the costs associated with power outages to utilities.
	Distribution congestion Relief	Use of an ESS to store energy when the distribution system is uncongested and provide relief during hours of high congestion.
Customer Energy Management Services	Power Reliability	Power reliability refers to the use of an ESS to reduce or eliminate power outages to utility customers.
	Time-of-Use Charge Reduction	Reducing customer charges for electric energy when the price is specific to the time (season, day of week, time-of-day) when the energy is purchased.
	Demand Charge Reduction	Use of an ESS to reduce the maximum power draw by electric load in order to avoid peak demand charges.

https://apps.puc.state.or.us/orders/2017ords/17-375.pdf

D. Dispatch Plan RFP Overview

PGE will issue an RFP to receive proposed scopes of work from technical evaluation or engineering firms (Contractors) on their recommended approaches for: A) an evaluation measurement and verification (M&V) and data collection plan, and B) experimental dispatch plans designed to yield insights into the operational practices which maximize outcomes for the Pilot's target use cases, which include, but are not limited to:

- Distribution use cases:
  - Localized demand response
  - Autonomous Volt/Var support
- Generation use cases:
  - Generation capacity
  - Energy resource optimization
  - Contingency reserves
  - Autonomous frequency response
- Customer use case:
  - Outage mitigation

Evaluation learnings and dispatch plan output will provide operational insights, and measure utility and customer cost/benefits related to:

A) Variation in costs and benefits from stored capacity under simulated events and conditions
B) Added system value and limitations of dispatching batteries for improving energy and ancillary services
C) Validation of customer benefits in terms of reliable outage mitigation and bill savings
D) Effectiveness and safety of system maintenance protocols
E) Suitability of Pilot's risk management plans
F) Depth of PGE's infrastructure and readiness to profitably integrate and operate distributed batteries at scale

PGE will also adhere to the learnings discussed within UM 1856 - PGE's Energy Storage Proposals and Revised Energy Storage Potential Evaluation.

PGE is seeking both the M&V plan and experimental dispatch plan at the outset of the Pilot to ensure it logs data critical for its evaluation and can leverage feedback and insights from these plans to improve the Pilot's ongoing learnings and operations. The plan should provide a roadmap for enhancing PGE's understandings and protocols for deploying resources with shared customer and utility value streams, integrating new and existing distributed resources, and managing distributed assets for improved grid services

PGE's will select a single firm or a team of firms to complete this work, considering the following criteria:

- Overall strength of proposal (completeness, well-conceived approaches, analytical details)
- Experience evaluating electric distribution network performance
- Experience documenting impact evaluation methodologies
- Citation of relevant industry practices and standards in proposal
- Relevant experience of the specific, firm's staff

- Proposed project costs

The scope of the project to be performed is described below:

1. Kickoff meeting to define objectives PGE is targeting for deliverables
2. Document data requirements for evaluating target applications / use cases
3. Submit draft evaluation M&V plan to PGE for comments
4. Submit draft experimental dispatch plan
5. Confirm suitability of PGE's current and future data logging capabilities relative to needs of evaluation and dispatch plans
6. Submit final evaluation and dispatch plans

PGE invites bidders to propose the most appropriate methods for conducting work. Bidders shall indicate where access to data, reports, or other resources are necessary interviews are proposed.

After the kickoff meeting the contractor will provide PGE with an updated draft work plan reflecting discussion and decisions made at the kickoff meeting. The updated and final work plans should include the following sections:

- Modeling strategies
- Document target ESS applications / use cases for development of dispatch plan
- Confirm operational feasibility of plan's protocols with PGE
- M&V and data collection plan goals
- M&V plan development, topics for literature searches, and data acquisition
- Schedule of tasks and deliverables (draft and final), including PGE review periods

After PGE's review, the contractor will provide a final work plan addressing feedback from PGE staff. The work plans should clearly detail the data/information required from PGE and its contractors so that PGE staff can actively support the contractor's efforts.

The contractor will draft an experimental protocol for dispatching batteries in the pilot for the purpose of determining the optimal approaches for generating benefits for targeted by the Pilot's use cases. The developmental process is as follows:

1. Develop experimental design to estimate and measure values and benefits of target applications.
2. Deliver models and files for modeling outputs from experimental dispatch, include. documentation for interpreting output with regards to stacked use cases with multiple applications.
3. Discuss dispatch plan design and modeling approaches with PGE to ensure operational/logistical feasibility.

The M&V and Data Collection Plan will be adopted for use in future impact evaluations of the Pilot. The Plan's document will describe M&V models in detail, including all parameters and estimates affecting the use and accuracy of outputs relative to the needs of the Pilot. The data collection plan will clearly specify how PGE or its contractors should log and collect data if necessary, describe the frequency of data collection, any quality assurance practices, and clearly identify any secondary sources important for impact evaluations.

Wherever possible, the M&V and Data Collection Plan should reference these sources of information:

- Battery Pilot Data Collection – Collection of operational data from enrolled batteries to utilize as inputs for quantitative analysis and modeling, including collection of data from both normal operation and from simulated events/activities designed evaluate specific capabilities and/or benefits;
- PGE Modeling – Analysis of system-level and battery-specific data by PGE within its available suite of modeling tools;
- Independent Modeling – Data analysis performed by consultant, which will consider both data directly obtained from battery data collection and outputs from PGE modeling;
- Secondary Research – Review of available data and literature from reputable resources to identify appropriate assumptions and inputs, as well as to gather lessons learned and best practices from other battery deployments
- Interviews – Interviews with and/or surveys of project stakeholders (e.g., PGE staff, customers) to identify project successes and areas for improvement, as well as to estimate the value of benefits that may not be directly measured or modeled
- Workshops – In-person workshops with a group of stakeholders within PGE to identify lessons.

E. Other Available Incentives

Two mechanisms will be available to help customers reduce the initial cost of a battery energy system during the pilot:

- Federal ITC
  - On a ramp down schedule starting in 2019, will decrease to zero in 2022.
  - Customers receiving this tax credit must restrict the battery to only charge passively from their solar panels for five years after claiming the credit.
- Oregon Solar + Storage rebate, HB 2618
  - Recently passed legislation providing rebates for customers installing solar panels, with additional funding for solar + storage.
  - Duration of program is two years, but total funding of $1.5mm is anticipated to quickly be claimed.

No other widely available grants or funding streams were identified.

Solar Investment Tax Credit

The Federal ITC was launched in 2006 for the primary purpose of supporting the growth of the solar industry. In 2018 the internal revenue service released a private letter ruling[48] stating that battery energy storage systems are eligible to receive the ITC when paired with and exclusively charged by solar photovoltaic systems. The impact of this tax credit is that the usable capacity of a customer's battery will be restricted to what can be provided and stored by the customer's solar array, and may make using the battery unusable for energy storage in winter months (at least for five years until the battery is no longer bound by the ITC). The residential portion of the ITC is set to phase out in the upcoming years, but PGE anticipates that many customers will opt to restrict their batteries in this fashion. PGE will rely on the customers' programming of the batteries for tax credit compliance and will only use the power made available by the battery programming. After the customer's battery is no longer restricted to passive solar charging the customer may opt to re-program their battery to allow for grid charging, and receive a higher incentive value to reflect the higher value of grid services the battery will now provide.

While the tax credit will phase is on a phase down schedule it will also be important to study and understand the realized value that PV-restricted battery provides compared to non-restricted battery, in the event that the ITC is renewed or other similar funding streams emerge.

Oregon HB 2618[49]

The Oregon legislature passed House Bill 2618 in June of 2019, making available $1.5mm over two years in rebates for solar and solar plus storage, when installed at the same time and by the same installer. Twenty-five percent (25%) of the funds, or $375,000 is set aside for income qualified customers, including income qualified service providers who may be building or developing housing for income qualified end users. The incentive is the lesser of the stated amount or the net cost of the project. The ITC and ongoing utility incentives that compensate for grid services do not count as a reduction in net cost.

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48 https://www.irs.gov/pub/irs-wd/201809003.pdf
49 https://olis.leg.state.or.us/liz/2019R1/Downloads/MeasureDocument/HB2618/Enrolled

Table 6 Solar and Storage Rebates per Market Segment

Market Segment	Solar Rebate	Storage Rebate
Residential- Market	Lesser of $5,000 or 40% of the net cost	Lesser of $2,500 or 40% of the net cost
Income qualified (Customer or Service Provider)	Lesser of $5,000 or 60% of the net cost	Lesser of $2,500, or 60% of the net cost
Commercial Income qualified	Lesser of $30,000 or 50% of the net cost	Lesser of $15,000 or 60% of the net cost

Energy Storage Tax Incentive and Deployment Act of 2019[50]

A residential tax credit that would apply for residential energy storage was introduced in the 2019 Federal Congressional session that would amend the Internal Revenue Code to allow tax credits for energy storage technologies and battery storage technology, and thus would remove the limitations of the solar ITC for grid connected battery storage. This bill has not yet moved forward to legislation.

The bill expands the tax credit for investments in energy property to include equipment that receives, stores, and delivers energy using batteries, compressed air, pumped hydropower, hydrogen storage (including hydrolysis), thermal energy storage, regenerative fuel cells, flywheels, capacitors, superconducting magnets, or other technologies identified by the Internal Revenue Service; and has a capacity of at least five kWh.

PGE would evaluate the impact on the Pilot should the bill eventually be enacted.

[50] https://www.congress.gov/bill/116th-congress/house-bill/2096

F. Solar Within Reach Overview

Solar Within Reach

EnergyTrust of Oregon

This fall, the Solar program launched a new offering that provides increased incentives to income-qualified homeowners who install solar panels on their homes.

Objective

We aim to make rooftop solar accessible to homeowners who have, traditionally, found solar was just out of reach. Energy Trust is committed to serving and benefiting all eligible utility customers and being inclusive in our program offerings. We know that there is more we can do to ensure people with low and moderate incomes, communities of color and rural communities can participate with us.

Background

This incentive offering was developed with the expert input from more than a dozen community-based organizations, local governments and others. It was launched in late October of 2019. Outreach, education and marketing to promote the offer are planned for 2020.

Incentive Summary

Budget

Energy Trust has budgeted approximately $500,000 per year for the next three years for this offering. Our target is to see 100 customers participate in Solar Within Reach in the first year.

Eligibility

To qualify, customers must be Oregon customers of PGE or Pacific Power, own their home and have a household income ≤100% state median income. The home can be a single-family home, manufactured home, floating home or multifamily residence. Income is verified via a form that is completed by the customer and submitted by the trade ally with the incentive application.

Customers must work with a Solar Within Reach trade ally. These top-performing, five-star trade allies have received additional training, provide longer warrantees and agree to additional service standards.

Incentive amount

The incentive amount depends on the size of the system installed. To start, the **incentive rate is $1.50/watt, with a maximum of $9,000 per home**. The incentive is paid directly to the contractor, who deducts the incentive amount from the invoice and reduces the customer's out-of-pocket cost. Incentives are subject to funding availability and may change.

Consumer Protection

It is important to take additional steps to protect customers who may be more vulnerable and subject to predatory sales practices. For this reason, Solar Within Reach contractors are the highest-rated solar trade allies in our network. In addition to maintaining their high rating, these contractors must participate in special training, sign a service agreement with Energy Trust, provide longer warranties and agree to stronger customer service standards.

To ensure that these solar energy systems perform well for decades to come, Energy Trust reviews all equipment and system designs to catch errors before construction, and then visits most projects to conduct a post-installation verification. If problems are found, they must be corrected by the trade ally.

G. Portland CERT Letter of Support

PORTLAND BUREAU OF EMERGENCY MANAGEMENT
Jo Ann Hardesty, Commissioner-in-Charge • Mike Myers, Director
9911 SE Bush Street, Portland, OR, 97266-2562
(503) 823-4375 • Fax (503) 823-3903 • TDD (503) 823-3947

August 28, 2019

Public Utility Commission of Oregon
PO Box 1088
Salem, OR 97308-1088

Dear Commissioners:

The Portland Bureau of Emergency Management (PBEM) manages the Neighborhood Emergency Team (Portland NET), a group of approximately 2,000 emergency response volunteers. NET volunteers will serve as crucial resources to the City of Portland following a Cascadia Subduction Zone earthquake or other disaster.

I am writing to support PGE's proposed pilot project to place a fleet of batteries on residential customers' homes. The batteries will be used by PGE for renewable power integration and grid stabilization purposes.

PGE plans to offer an incentive package to customers to help make the batteries more affordable. They have proposed to make the incentives available first to NET volunteers in their service area.

In their communities, NET volunteers are disaster preparedness and response leaders. By making available the opportunity for NET volunteers to have electricity in the event of a major outage, the reach and benefit of these batteries may be significantly expanded. I appreciate and support PGE's recognition of NET's important role by offering the incentive package to them.

Thank you for considering my support of this project.

Sincerely,

Mike Myers, Director
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